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DETERMINATION OF THE OZONE PROFILE FROM THE
OUTGOING THERMAL EMISSION

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DETERMINATION OF THE OZONE PROFILE FROM THE
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Problems are discussed concerning the information content of measuring the spectral and angular distribution of the outgoing thermal emission of the atmosphere-Earth system in the $9.6 \mu\text{m}$ ozone absorption band. Two schemes of remote measurements (nadir and limb) are considered. The independent and combined information contributions of data, obtained in conformity with both measurement schemes, are evaluated. Results are discussed from numerical stimulation of the solution of the inverse problem in availability of a number of perturbation factors (inadequacy of the transmission functions, a priori statistics, errors of radiation measurements) for various conditions of remote measurements (spectral intervals experiment geometry). Effectiveness of the regression interpretation method, which uses the data of nadir and limb measurements simultaneously, is demonstrated.

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In recent years, interest in studying the possibilities of remote probing of ozone in the atmosphere has increased noticeably. Although ozone belongs to the small gas components of the atmosphere, its role is significant for a whole series of reasons. Besides the fact that the layer of ozone protects the surface of Earth from intense ultraviolet radiation of the Sun, its presence to a significant degree determines the existence of a positive

*Numbers in the margin indicate pagination in the foreign text.

temperature gradient in the stratosphere, and has an effect on large- and average-scale dynamics of the atmosphere. Ozone enters into reaction with nitrogen oxides and water vapor and the latter makes an important contribution to the energy planetary balance not only in the gas phase but also as a basic component of cloud formations. The connection of the total content of ozone in the upper troposphere and stratosphere with the processes of circulation was demonstrated recently in reference [10].

A comparison of the geopotential field for the isobaric 200mb surface and global distribution of ozone reveals a whole series of general characteristic traits which have important forecasting value. The complex interaction between the content of ozone and the dynamic mechanics of the atmosphere explains the significant interest in measuring the total content and the vertical stratification of ozone on a global scale. This also requires investigation relating to the study of heat exchange between the troposphere and the stratosphere. Knowledge of the distribution of atmospheric ozone is necessary for explaining the structure and determining the quantitative parameters which characterize photochemical reactions in the stratosphere.

Global measurements of ozone are carried out only using artificial satellites. At the present time, a number of methods of remote probing of ozone in space are being proposed. One of these involves information analysis as to the distribution of ozone in the upper stratosphere contained in measurements of scattered solar radiation carried out in different directions. Another method of recovering information on the vertical profile of ozone is based on interpretation of measurement data of solar radiation attenuated on sliding slope paths. In both cases, obtaining information is determined by the presence of an absorption mechanism of attenuation of radiation in the bands of ozone absorption.

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The method which involves analysis of spectral and angular distribution of outgoing thermal emission of the atmosphere-Earth system in the $9.6 \mu\text{m}$ band of O_3 absorption has a number of advantages which have attracted the attention of scientists. Being simpler from the point of view of a technical realization, this method makes it possible to carry out remote probing in any geographical region of a planet on the diurnal and nocturnal sides. Inasmuch as the scattering processes can be ignored in the infrared area of the spectrum, the method of interpreting the results of measurements is simpler. One can note three important aspects of research carried out in recent years in connection with practical realization of a given problem. Numerical experiments on the EVM [Elektronnaya vychislitel'naya mashina, electronic computer] made it possible to discover the effect of certain sources of error in the initial information on precision in establishing the ozone profile [11,12]. Studies of the characteristics of absorption of atmospheric ozone [7,13] showed the difficulties of a model presentation of functions of transmission in conditions of the actual atmosphere. Practice in interpretation of the data of actual satellite measurements [9,10] gives us information as to the effectiveness of the remote method when determining the total content of ozone and as to the presence of problems in constructing analytical approximations for transmission functions which limit the possibilities for establishing a vertical profile.

The purpose of this work is a systematic consideration of the questions of information content of remote measurement data including problems of optimizing the statistical algorithm of interpretation, evaluation of the coverage of the experiment with different measurement conditions, analysis of the precision of solving the inverse problem with the presence, in the model being used, of elements of inadequacy characteristic for the actual situation.

Stochastic Linearization

The problem of interpretation of measurement results of characteristics of outgoing thermal emission, in order to establish a vertical profile of ozone in the atmosphere from a mathematical point of view, amounts to solution of a system of nonlinear equations which we write formally in a vector form

$$y = A[x] + \epsilon. \quad (1)$$

The set of parameters evaluated $x = (x_1, \dots, x_n)$ characterizes vertical distribution of a given gas in n layers of the atmosphere. We will consider that the vector of measured y values has a dimension equal to s ($s = mk$, m -- is the number of spectral intervals, k -- is the quantity of spatial points or directions when scanning the horizon). The components of the ϵ vector characterize the total error and measurement and errors in the mathematical model used. For an approximate solution of systems of nonlinear equations, a whole series of numerical methods have been developed [2]. However, the presence of stochastic member ϵ , and also the a priori statistical information on x indicates the advisability of using probability methods of solving problem (1). We will consider the possibilities of using the method of stochastic linearization [4] for obtaining a statistically optimum solution /13 of $\hat{x}$ and also we will consider the information characteristics resulting from this approach.

Inasmuch as the statistical method is used for solving the problem we will consider as known certain probable characteristics of the random vectors x and y going from certain a priori sampling. Let us assume that the a priori sampling of the x vectors consists of N realizations; $\{x^i\}_{i=1}^N$ ($N \gg n, s$). Assuming model (1), one can obtain the appropriate statistic for y (y^i) $i=1, \dots, N$.

Having at one's disposal both these samples, one can calculate, following the known formula from the statistics, the empirical evaluations for the first two moments of the random vectors x and y (mean vectors $\bar{x}=E(x)$, $\bar{y}=E(y)$, and also auto- and inter-covariance matrices $R=E\{(x-\bar{x})(x-\bar{x})^*\}$, $Q=E\{(y-\bar{y})(y-\bar{y})^*\}$, $K=E\{(y-\bar{y})(x-\bar{x})^*\}$). We will also consider that the two first moments of vector error ε are known: $E(\varepsilon)=0$, $\Omega=E\{\varepsilon\varepsilon^*\}$. We will introduce random vector x using the equality $x=\bar{x}+\Delta x$. The linearized concept of the relationship which determines equality (1), we will find in the form of the relationship

$$y=b+C\cdot\Delta x, \quad (2)$$

where the set of unknown coefficients forms vector $b=\{b_1\}$ and matrix $C=\{c_{ij}\}$ ($i=1, \dots, s$, $j=1, \dots, n$). It is obvious that the unknown parameters b and C depend on the probability characteristics of random vectors x , y , ε . For determining them, we will use the criterion of minimum root-mean-square error approximation

$$\xi=E\{\|A(x_1, \dots, x_n) + \varepsilon - b - C \cdot \Delta x\|^2\}. \quad (3)$$

($\|\cdot\|$ -- is the vector Euclidean norm). Opening the brackets in the right part of equation (3) and equalizing the possible derivatives to zero $\frac{\partial \xi}{\partial b_i}$ and $\frac{\partial \xi}{\partial c_{ij}}$, we come to a system of equations $b=E\{A(x_1, \dots, x_n)\}$, $C \cdot R = K$, from which follow the estimates sought:

$$\hat{b}=\bar{y}; \hat{C}=K \cdot R^{-1}. \quad (4)$$

On the other hand, it is known that with the a priori statistically optimum solution $\hat{\Delta x}$ of system (2) the formula is written

$$\hat{\Delta x}=R \cdot C^* \cdot (C \cdot R \cdot C^* + \Omega)^{-1} \cdot (y - \hat{b}). \quad (5)$$

Substituting (4) and (5), we come to the desired representation for an estimate of the x vector which is an approximate solution of the initial problem (1):

$$\hat{x} = \bar{x} + K^* (K \cdot R^{-1} \cdot K^* + \Omega)^{-1} \cdot (y - \bar{y}). \quad (6)$$

The quality of estimate (6) is characterized by the appropriate residual covariance matrix

$$\hat{R} = R - K^* (K \cdot R^{-1} \cdot K^* + \Omega)^{-1} \cdot K. \quad (7)$$

We will compare the given approach with a method of analytical linearization. In this case, for small variations of Δx and Δy , an approximate equality is used

$$\Delta y \approx A' [x_0] \cdot \Delta x + \tilde{\epsilon}, \quad (8)$$

in which $A' [x_0]$ -- is the matrix operator of partial derivatives at a certain point x_0 . The statistical method of solution of (8) is described by predictor /14

$$\hat{\Delta x} = \hat{R} \cdot (A')^* [A' \cdot R \cdot (A')^* + \Omega]^{-1} \cdot \Delta y. \quad (9)$$

Stochastic interpretation (8) results in approximate equality $K = A' \cdot R$, which makes it possible to establish the interrelation of (6) and (9). If one assumes that $y = A[\bar{x}]$ and is true for (8), where ϵ --is random and independent of Δx , the error of approximations, then (6) leads to (9). In this way, an evaluation of (9) is an approximation in relation to (6). We note that (6) is the best of the estimates based on the first two moments of random vectors x and y . Estimate (9) is not optimum for the concept indicated. Both estimates coincide in the case where operator A (1) is linear in relationship to x .

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We will look at certain characteristics of the information content of the given remote measurements. The quantity of information according to Shannon as to the component of solution x_1 , contained in values of vector y , is described by equality $I(x_1, y) = \log_2 (r_u / \hat{r}_u)$ in which the diagonal elements are introduced, r_{11} and $\hat{r}_{11}^2$ of matrices R and $\hat{R}$. The size $d_1^2 = 1 - (\hat{r}_u / r_u)^2$ is the multiplier coefficient of the correlation of scalar quantity x_1 and vector y . It is obvious that d_1^2 changes in the interval $[0, 1]$. The ratio $g_1^2 = (r_u / \hat{r}_u)^2$, which describes the relative residual dispersion, acts as a visual characteristic of the efficiency of the experiment and is the dual value in relation to d_1^2 in the concept that $d_1^2 + g_1^2 = 1$. Later on, we will use these universal characteristics for estimation and comparison of the precision of remote measurements with different conditions of the experiment.

Information Content of Data of Remote Probing

The basis for solving inverse problems of atmospheric optics in the infrared range is the integral form of the transport equation. We consider the two different geometrical measurements of the characteristics of outgoing thermal emission from space. The measurement system as to the nadir is simpler from the point of view of technical realization. In this case, for intensity of the intrinsic radiation of the atmosphere-Earth system $L_{\Delta\nu}$ in the spectral interval $\Delta\nu$ the following equation is true.

$$L_{\Delta\nu} = B_{\Delta\nu} [T(p_s)] \tau_{\Delta\nu}(p_s) - \int_0^{p_s} B_{\Delta\nu} [T(p)] d\tau_{\Delta\nu}(p), \quad (10)$$

in which $\tau_{\Delta\nu}(p)$ -- is a function of a transmission of the atmosphere by a layer from the upper boundary to the level with pressure p ,

$B_\nu [T(p)]$ --is the Planck function of transmission of an absolutely black body at temperature T for frequency ν ,

p_s --is the level of atmospheric pressure in the layer adjacent to the underlying surface.

The system of measurement of angular distribution of outgoing emission in a horizontal direction (measurement of the limb) is more complex. The expression for intensity of emission recorded from space in the direction of the line of sight for tangential height h has the following form:

$$L_{\Delta\nu}(h) = - \int_{z_0(h)}^{z_1(h)} B_\nu [T(z)] d\tau_{\Delta\nu}(z) \quad (11) \quad /15$$

Here, z --is the variable geometric path,

$z_0(h)$, $z_1(h)$ --are boundary points at the line of sight in the atmosphere corresponding to height h ,

$\tau_{\Delta\nu}(z)$ --is the function of transmission of the upper atmosphere along the beam of observation in spectral integral $\Delta\nu$.

We will consider that the temperature profile T is given. We will assume that the analytical concept for the dependence of the function of transmission on the mass of absorbed gas presented $\tau_{\Delta\nu} = \tau_{\Delta\nu}(u)$ is known [1]. In this case, equations (10) and (11) lead to a model in the form of (1) where the role of unknown parameters is played by values of concentrations of absorbed gas relating to the n layer of the atmosphere $x_i = q(z_i)$ ($i=1, \dots, n$). Therefore, for solving the problem of remote probing, one can use the mathematical formalism developed in the preceding section.

We will pause to consider the initial data used for a numerical realization of a statistical algorithm. We consider two analytical models of the functions of transmission of ozone.

The Moskalenko model [1] corresponding to a spectral solution of 10 cm^{-1} , was considered as approximate (transmission model I). Goody's statistical model [7] with the corrections proposed in [6], makes it possible to calculate the Foygtovskiy character of the contour of spectral lines. This model we considered conditionally as precise (transmission model II). The spectroscopic parameters relating to the $9.6 \text{ }\mu\text{m}$ ozone absorption band were borrowed from reference [5]. Calculation of the absorption of radiation by water vapor in the spectral zone being considered was accomplished using an analytical model of the functions of transmission [1] in which a climatic profile of moisture content in the atmosphere was used.

The realizations of the method formulated above of interpretations depends on the presence of a priori statistics as to the set of unknown parameters x . We used two statistical samples of vertical profiles of ozone corresponding to 20 standard levels of pressure in a range from 5 to 850 mb. The indicated data [8] relates to two stations: Khokhenpaysenberg ($47^{\circ}48'$ north latitude, $11^{\circ}01'$ east longitude) -- statistics A, Tateno ($36^{\circ}03'$ north latitude, $140^{\circ}08'$ east longitude) -- statistics B. The volume of each sampling amounted to 40 independent measurements carried out in a period from February to May, 1968--1969.

A regression model of type (1) based on equations (10) and (11) was constructed in accordance with the two measurements systems considered (nadir, limb). We will designate them regression models I and II, respectively. Also, a regression system of equations combining (10) and (11) was carried out, that is, the proposed use of both types of remote information simultaneously (regression model III).

As was noted in the preceding section, the values of d_1^2 are the visual characteristics of the information content of remote measurement data. The values of d_1^2 corresponding to three regression models for different sets of spectral integral 9.6 μm bands were calculated.

Figure 1 shows graphs of information characteristics corresponding to a separate spectral interval.

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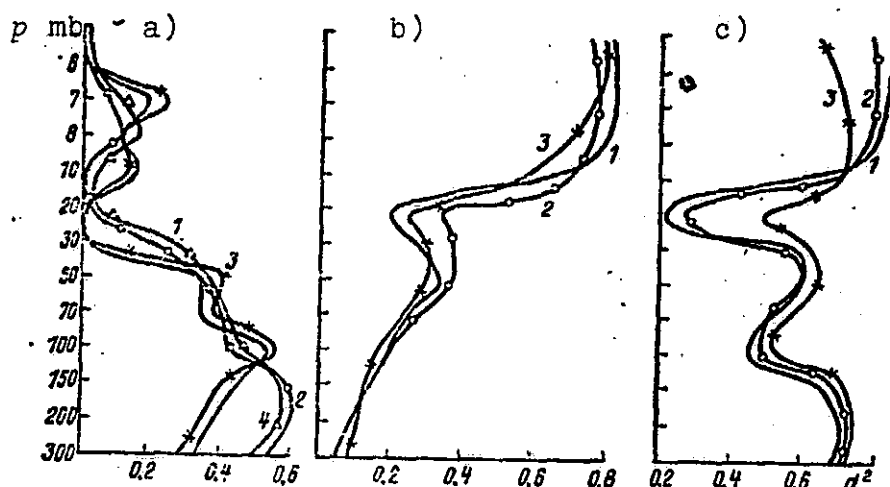


Figure 1. Vertical distributions of information coverage with measurement in separate spectral intervals. a--regression model I (1--1055 cm^{-1} , statistic A; 2--1055 cm^{-1} , B; 3--1065 cm^{-1} , A; 4--1005 cm^{-1} , B); b--model II (1--1055 cm^{-1} , A; 2--1065 cm^{-1} , B; 3--1055 cm^{-1} , B); c--model III (1--1055 cm^{-1} , B; 2--1015 cm^{-1} , B; 3--1065 cm^{-1} , B).

In the case of regression model I, (Figure 1a), the informants have a characteristic vertical structure. The distributions have a maximum in the interval of heights which determine levels of atmospheric pressure 100-200 mb. Moreover, an increased

information coverage is observed in layers of atmosphere located above the 20 mb level. Although the information characteristics which correspond to statistical sampling A and B, differ quantitatively from each other, their vertical structure is very similar. One should note that for all spectral intervals and both statistics, the information curves have a characteristic minimum in the 30-50 mb interval which contain the position of maximum concentration of ozone.

Regression model II is characterized by informants (Figure 1b) which reveal the dependence on the spectral interval only in layers of atmosphere which are located above the 10 mb level. Measurements of angular distribution of outgoing emission contain the largest quantity of information on that section of the ozone profile which is located above the position of maximum concentration. Here, also one notes a certain decrease in the information coverage of a 30-50 mb atmospheric layer. A comparison of Figures 1a and 1b shows a noticeable information advantage in relation to the lower stratospheric measurement in the nadir. For regression model III (Figure 1c), a more uniform structure of information coverage of different layers of the atmosphere is characteristic. Thanks to synthesizing both types of remote information in this model, the upper and lower stratosphere appears to be covered approximately uniformly. A decrease in values of informants is noted in the 30-70 mb layer which contains the position of maximum concentration of ozone.

Figure 2 presents curves of information coverage corresponding to measurement systems for a number of combinations of spectral intervals.

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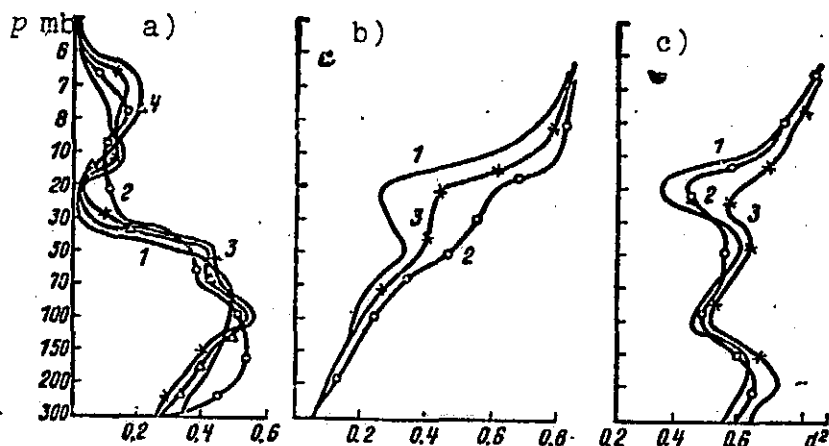


Figure 2. Vertical distributions of information coverage with measurements in a set of spectral intervals. a-- regression model I (1--1045, 1065 cm^{-1} , B; 2--1015, 1055 cm^{-1} , A; 3--1055, 1075 cm^{-1} , B; 4--1055, 1065 cm^{-1} , A); b--model II (1--1045, 1065 cm^{-1} , B; 2--1055, 1005 cm^{-1} , B; 3--1055, 1065 cm^{-1} , B); c--model III (1--1045, 1065 cm^{-1} , B; 2--1055, 1065 cm^{-1} , B; 3--1015, 1055 cm^{-1} , B).

A combination of "transparent" and "opaque" sections of the spectrum in regression model I (Figure 2a) more uniformly provides information on the layer of the stratosphere except for the 20-50 mb interval. When transferring to the troposphere, the information characteristics rapidly diminish. The informants which correspond to regression model II (Figure 2b) are practically unchanged with the addition of a second spectral interval which explains the similarity of information containing different sections of the spectrum with measurements of the limb. In the

case of regression model III (Figure 2c) one can note a definite /17
dependence of the information curves in the lower stratosphere
on the combination of spectral intervals. The structure of the
informants in the upper stratosphere changes less significantly.

Summarizing the results of the study made, one can note the
dominant role of information as to the content of ozone in the
upper stratosphere obtained from measurements of angular distribu-
tion of outgoing emission and the supplemental values of measure-
ment data in the nadir for evaluating the ozone profile in the
lower stratosphere. Both types of data make up inadequate informa-
tion on the troposphere and the atmospheric 30-70 mb layer. The
results of calculations also make it possible to draw a prelimin-
ary conclusion as to the fact that the measuring system must
include two spectral intervals in the 9.6 μm band: "transparent"
and "opaque" sections of the spectrum. However, for determining
the width and position of these intervals, it is necessary to
use special methods of optimization. Another means of establish-
ing the effectiveness of remote methods is a numerical model on
an EVM for solving the inverse problem.

Factors Which Determine Precision of Solving the Inverse Problem

In references [11, 12] the question of the effect of error
in assigning a number of initial parameters on the precision of
setting up the ozone profile was studied in detail. It was
found that the most significant value can be error in assigning
the vertical distribution of temperature which in practice
amounts to 2-4° C. Their presence results in a decreased pre-
cision in determining the ozone profile by 50-100% [11]. When
interpreting the angular distribution of outgoing emission,
the quality of conjunction of measurement data to the values of
type of the line of vision plays an important role. With errors

in a value of h , equal to ± 1 km, the error in setting up the ozone profile increases by 20-40% [11]. The method of analysis proposed in [3] of simultaneous spectral measurements of outgoing transmission in the absorption bands of two gas components (an unknown quantity and CO_2 which has a relatively constant concentration in the atmosphere) in principle provides solution of both problems indicated. Therefore, one can assume that in the future, their role will remain significant. Numerical simulation of the solution of the inverse problem indicates [11] that errors in a number of the initial data (errors in radiation measurements, the presence of variation in the content of water vapor, errors in assigning ground pressure and temperature) appear to be less significant and result in a decrease in precision of the establishing by 5-10%.

Let us consider other important sources of error which occur when solving the inverse problem. It is known that analytical concepts of the functions of transmission only approximately describe the characteristics of absorption of the actual atmosphere; this results from a model description of contours and character of mutual positioning of spectral lines in the absorption bands, the dependence of spectroscopic parameters on temperature and pressure. In the case of ozone, one observes an anomalous behavior of functions of transmission caused by the presence of large masses of gas being considered with low atmospheric pressures [13]. This circumstance limits the possibilities of using the classical Curtis-Goodson method for calculating optical irregularity in the atmosphere [13], and requires considering the Foygtovskiy contour of spectral lines [6]. During interpretation of the data of actual satellite measurements, the inadequacy of the analytical model used was confirmed [9]. The presence of simultaneous measurements of the ozone profile and temperature at a series of aerological stations, and also the intensity of the outgoing emission from the satellite

provided a calculation of optimum values of the parameters used for the transmission model. However, this kind of solution has only a local value. Therefore, it is advisable to evaluate the possible losses in precision involved with the inadequacy of transmission functioning. One can assume that the disparity in the results between the two models of transmission functions does not exceed the deviation of each of them from the real transmission of the actual atmosphere. In this case, numerical experiments with two models of transmission functioning (solution of the first problem using the "precise" model I and the inverse problem on the basis of the "approximate" model II) make it possible to obtain the lower boundary of the errors being considered. /19

In view of the fact that the method used for interpretation is statistical, precision of the results obtained, to a significant degree, is determined by the adequacy of the a priori statistics used. Inadequate coverage of a priori information with practical realization of remote methods results in the necessity for using "foreign" statistics. For evaluation of the possible decrease in precision caused by the presence of this factor, we have carried out numerical experiments in establishing profiles of ozone taken from sampling A using a priori statistics B.

Figure 3 shows the results of setting up three profiles of ozone on the basis of regressive model I. The results of calculations of outgoing emission in two spectral intervals centered at $\nu=1045$ and 1065 cm^{-1} as the initial information were used. From the results presented, it is apparent that the inadequacy of the model of transmission functioning used is the most significant perturbing factor. In this case, relative deviations of values of the profile established from the initial amount to 50-100%. A less noticeable decrease in precision is caused by the use of "foreign" statistics. Relative errors in evaluating appear to

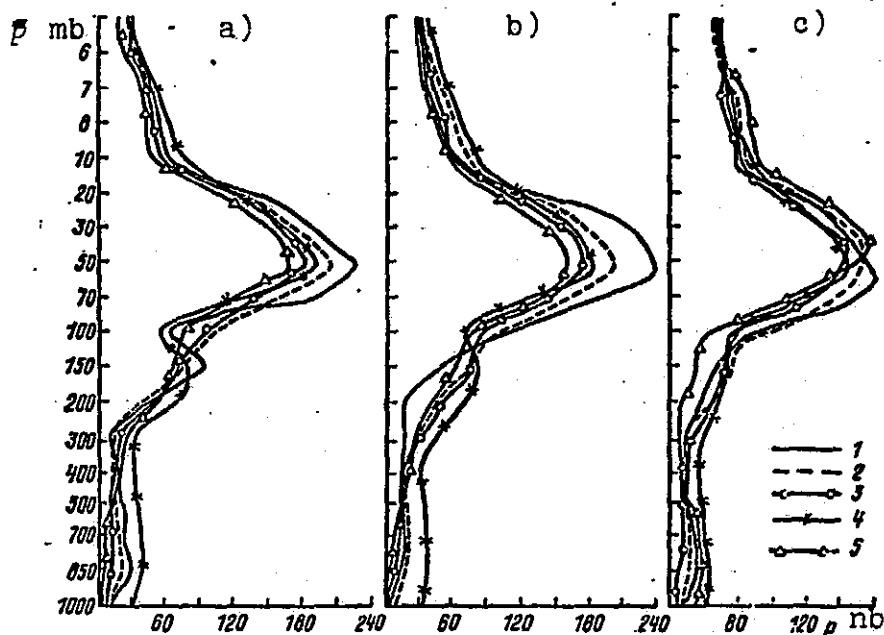


Figure 3. A numerical experiment in establishing three profiles of ozone on the basis of regression model I. 1--true distribution; 2--solution corresponding to the 0.5% level of measurement error; 3--solution corresponding to the 2% level of measurement error; 4--solution obtained according to "foreign" statistics; 5--solution with the presence of an inadequate model of transmission functioning.

be equal to 40-60%. A comparison of curves 2 and 3 makes it possible to conclude that the level of measurement errors is the least significant factor affecting precision in solving the inverse problem. With the presence only of radiation errors, precision of establishment is characterized by relative sizes of 10-30%. Considering the vertical structure of establishment error, we find that the largest divergence of a true profile and an approximate solution is observed in the 30-50 mb layer which contains the level of maximum concentration of ozone. We note that this is found in complete agreement with the results of analysis of information characteristics of the experiment carried out in the preceding section.

Similar calculations were made for a case of interpretation of angular distribution of heat emission. Figure 4 shows

examples of establishing vertical profiles of ozone on the basis of regression model II.

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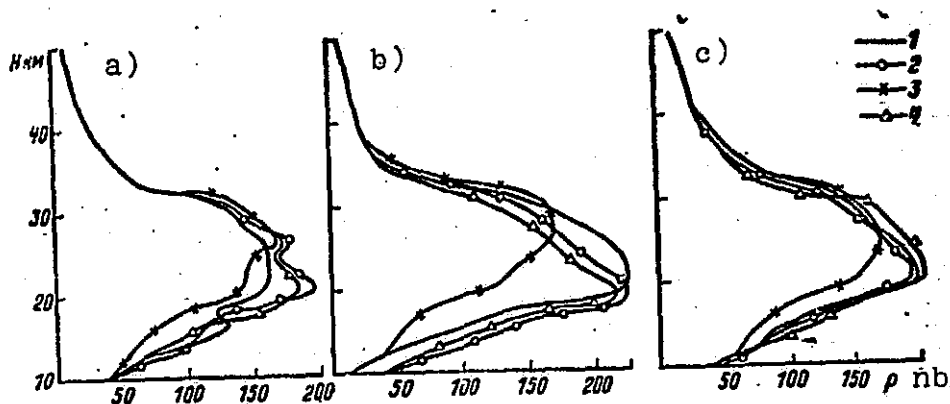


Figure 4. A numerical experiment for establishing three ozone profiles on the basis of regression model II. 1--true distribution; 2--a solution corresponding to measurement with error 0.5% in the spectral interval of 1015 cm^{-1} ; 3--a solution corresponding to measurement in the 1015 cm^{-1} interval, "foreign" statistics; 4--a solution corresponding to measurement in the 1065 cm^{-1} interval, adequate statistics.

The use of inadequate a priori statistics results in a significant divergence of the approximate solution (curve 3) and true distribution of ozone (curve 1). Relative errors of establishment amount to 20-50%. Random errors in measurement appear to have a less significant effect on the precision of solution obtained (curve 2). The results presented relate to the frequency of sampling 1015 cm^{-1} . The use of information on angular distribution of thermal emission for a spectral interval when $\nu=1065 \text{ cm}^{-1}$ (curve 4) leads to close results. The data of Figure 4 attests to the fact that in the area with altitude 20-30 km, one observes the least precision in establishing the ozone profile. The results obtained agree with conclusions made in the preceding section on the basis of analysis of information characteristics.

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Let us look at the possibilities of regression model III which combines both types of infrared information. Figure 5 shows vertical distribution of relative errors in establishing two ozone profiles.

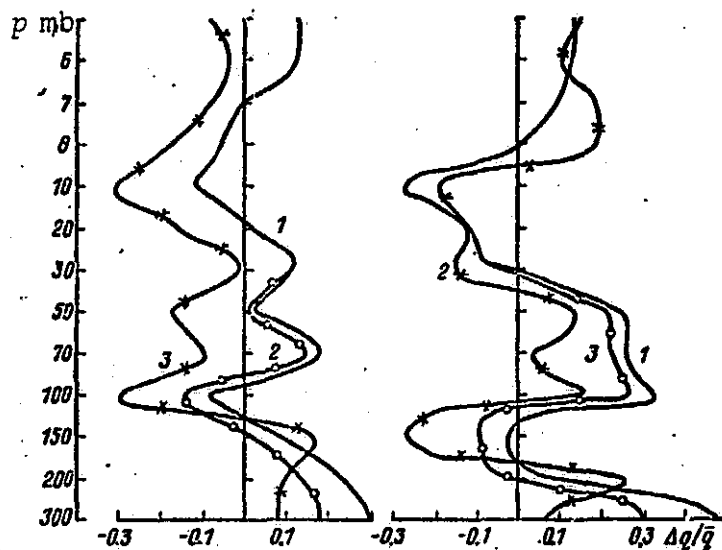


Figure 5. Vertical distributions of relative errors in establishing two profiles of ozone using three regression models. 1--model II, 2--model I, 3--model III.

The results presented correspond to the three regression models being considered. The data of radiation measurements apply to two spectral intervals centered at 1045 and 1065 cm^{-1} and they contained a random error equal to 0.5%. Thanks to the fact that information on angular distribution of heat emission contained the largest quantity of information on the upper and central stratosphere, the results of establishing ozone in these layers on the basis of regression models II and III differ very little from each other. In the atmospheric layers located below the level of maximum concentration of ozone, a definite equality in contributions of both types of remote infrared information is observed. As is apparent from the

results of calculations presented, precision of establishing an /21
ozone profile, using regression model III appears to be higher
than that which is characteristic for each of the models I and
II separately.

Conclusion

The two last sections of the work which explain the study
of effectiveness of the remote method of sampling ozone and based
on different method approaches, are characterized by a number of
mutually agreeing conclusions. Let us note them.

The data of measurements of angular distribution of out-
going emission contain, basically, information on the ozone profile
in the middle and upper stratosphere. Here, the structure of
spectral information appears to be very similar in different inter-
vals of the absorption band being considered. The measurements
carried out in the nadir and relating to a "transparent" spectral
interval supply information on distribution of ozone in layers
of atmosphere lying below the layer of its maximum concentration.
Such measurements in sections of the spectrum where there is
strong absorption contained information on the set of layers of
the middle and upper stratosphere. Certain measurements of the
limb and nadir contain, to a significant degree, independent
information on stratification of ozone. A method designed for
simultaneous interpretation of both types of infrared measure-
ments is characterized by considerably more uniform information
coverage on the vertical coordinate than either of the tradi-
tional approaches. The lowest precision in establishing the
ozone profile concerns the layer of atmosphere where it has a
maximum concentration. This indicates the existing difficulties
in evaluating the true position of the ozone layer.

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